

Risk Quantification Using EMV Analysis – A Strategic Case of Ready Mix Concrete Plants

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Abstract

Ready Mix Concrete (RMC) industry in India is continuously growing. This industry is exposed to risks from internal as well as external sources. It is important to address these risks, so that industry shall gain credibility and confidence of the customers, and shall have expected profit margins. Proposed paper presents a risk quantification approach for risks in RMC plants in India, using Expected Monetary Value (EMV) analysis. It is developed using guidelines available in literature in the area of risk management. It is a simple but effective approach for quantification of risks and it shall help to achieve the objectives of RMC business in terms of cost of production and supply of RMC. Once the risks are quantified, quantitative assessment can be done further to decide upon the appropriate response strategies to be adopted to treat the risk related issues in effective way. This approach is checked for practicability in RMC organizations.

Keywords: *RMC, Risk quantification, EMV Analysis, Response strategies.*

1. Introduction

IS 4926-2003 (Bureau of Indian Standard 2003) defines Ready Mix Concrete (RMC) as “Concrete delivered at site or into purchaser’s vehicle in the plastic condition and requiring no further treatment before being placed in a position in which it is to be set and hardened”. Ready Mix concrete is preferred over site mix concrete because it is environmental friendly. It is a solution to a messy and time consuming manufacturing of concrete at construction sites. It offers solutions to customer’s specific problems, ensures customer satisfaction and provides uniform quality. It also eliminates the need to store materials used to manufacture concrete at project sites. Currently, RMC is a matured industry both in Europe and USA. The data from National Ready Mix Association (March, 2007) indicate that RMC is a $ 30 billion industry in USA, with annual output of 351 million cubic Meters. In these countries, nearly 75% consumption of cement is through the RMC route (National Ready Mix Concrete Association:http//www.concnt.org). In the context of India, the trend of using ready mix concrete is growing steadily. Demand of RMC is increasing in housing as well as in infrastructural projects. This has given a big flip to RMC industry in India. Anticipating huge potential for RMC in India, many organized and unorganized players are foraying in this area.

Like other industries, RMC industry is exposed to various risks. In European countries, there is an awareness and understanding about importance of risks and its management. Operation managers on RMC Plants in the European countries are expected to work on risk management at production plant and delivery sites (http://www.learn4good.com / jobs / language / english / search / job / 13807 / 12 / 29 /2005 risk mgmt). In India, Risk Management at RMC plant is not given adequate importance. Information gathered from RMC plants in India in places like Mumbai, Navi Mumbai, Pune, Bangalore, and Noida, established by different companies reveals that a systematic risk management approach is not practiced in Indian RMC Industry. Unless the risks are addressed properly, the RMC industry in India shall not gain credibility, confidence of customers and will also cause reduction in profit margins.

The risk causes can be categorized into internal risk causes and external risks causes (Zia 1995). Thus, the risks related to RMC plants can be classified as internal as well as external risks. Internal risks and External risks can not be avoided completely; yet, suitable strategies can definitely be adopted to manage these risks. This paper proposes an approach to quantify risks in RMC plants in Indian context. Once risks are quantified, quantitative assessment can be done so that the appropriate risk response strategies can be adopted to treat the risks related issues. This shall help in achieving the objectives of RMC business in terms of production and supply cost.

1. Literature review

In the literature, the word 'Risk' has been used in many different meanings with many different words such as hazard or uncertainty (Boodman 1977, Faber 1979, Lifson and Shaifer 1982, Hertz and Thomas 1983). The Webster's dictionary defines risk as 'The possibility of loss, injury, disadvantage or destruction'. According to Jamal and Keith (1990), risk can be written as,

Risk = f (Uncertainty of event, Potential loss/gain from event)

The concept of risk varies according to viewpoint, attitudes and experience of an individual and thus risk has a different meaning to different people. Engineers, designers, and contractors view risk from the technological perspective, Lenders and developers tend to view it from economical and financial side, and health professionals, environmentalists, chemical engineers take a safety and environmental perspective. Risk is, therefore, generally seen as an abstract concept whose measurement is very difficult (Baloi and Andrew, 2003).

The term 'risk management' has multiple meanings. Many use this term synonymously with risk identification. For many others, it is synonymous to risk analysis, risk monitoring and /or risk control. In fact, these all are the phases of risk management. According to Hillson(b) (2000) , the risk management is a process aimed to identify and assess risks in order to enable the risks to be clearly understood and managed effectively. Risk Management continues to be a major feature of the project management of large construction, engineering and technological projects in an attempt to reduce uncertainties and to achieve project success (Akintoye, 2008). According to Royer (2000), risk management is the critical part of project management as 'unmanaged or unmitigated risks are one of the primary causes of project failure'. PMBOK (PMI 2004) defines project risk management as 'the process concerted with identifying, analyzing and responding to uncertainty throughout the project life cycle'. A number of variations of risk management approach have been proposed by different authors and researchers. Four processes of risk management i.e. Risk identification, Risk Analysis and evaluation, Response management, and System administration are proposed by Jamal and Keith (1990).

The general consensus in current literature, available in the field of risk management, incorporates four steps in the process of risk management. These are Risk identification, Risk Analysis, Risk Response planning and Risk Monitoring and control (Thevendran and Mawdesley 2004).Failure to perform effective risk management can cause projects to exceed budget, fall behind schedule, miss critical performance targets, or exhibit any combinations of these troubles (Carbone and Tippett, 2004).

Risk identification is one of the most import stages in risk management process. In this stage, all the potential risks that could affect the project objectives are identified. It is studying a situation to realize what could go wrong at any given point of time during the project. For risk identification, some of the methods used are Check list, Brainstorming, Tree Diagram, Cause – Effect Diagram, Failure mode and effect analysis, Hazard and operability study, Fault Tree and Decision Tree, Delphi Technique, and Interviews (Ahmed, Berman and Sataporn 2007). Identified risks should be classified into different categories so as to give elaboration of risks in more details and to aid in deciding upon risk response strategies according to categories of risks. Several authors have attempted various means of classifying risk. Some of these include Mason 1973, Ashley 1981, Johnson and Rood 1977. The identified and classified risks should be assessed further for designing future course of action i.e. to decide upon suitable response strategies. Assessment of risks can be qualitative and quantitative. Qualitative risk assessment is rapid and cost effective. It includes assigning the probability and consequences for individual risks and finding out the risk exposure. Risk exposure gives an idea for screening the risks according to their priority so that risks having substantial influence on business objectives can be selected for quantification and quantitative assessment. These selective risks are quantified and are assessed further quantitatively using suitable techniques available for this. Some of the techniques used for risk assessment are Probability and impact Grid, Fault tree analysis, Event tree analysis, Sensitivity analysis, Simulation, Decision Tree analysis, Expected value Method, Analytical Hierarchy Process (Ahmed, Berman and Sataporn 2007).Businesses would like to quantify risks for many reasons. Knowing how much risk is involved helps to decide whether the costly measures to reduce the level of risk are justifiable or not (Jannadi and Alamshari 2003). Appropriate response strategies can be decided after assessment of risks. The

PMBOK (PMI 2004) has given four response strategies as risk avoidance, risk transfer, risk mitigation and risk Acceptance. Appropriate response strategies should be selected and implemented for the selected potential risks and are monitored continuously. Excellent risk strategies can reduce the probability and the impact of the risk occurrence causes at the same time (Molenaar 2009).

3. Proposed approach for risk assessment

The proposed approach in this paper considers risk as a future event which has an adverse effect on the production and supply cost for a company running RMC plant and for which possible outcomes can be predicted on the basis of probability. The proposed approach has three stages as below –
- Risk identification, categorization and classification
- Risk prioritization
- Risk quantification.

3.1 Risk identification, categorization and classification

As no previous record of the different types of risks in RMC plant in India is available, authors had to interview a team of plant managers and key personnel working at respective RMC plants. Risk management concept was explained to this team of plant managers and key personnel before interviewing them. Outcome of these interviews is a list of 121 risks in different categories and classifications. This established a base for risk quantification. A list of identified risks with their categories and classification is presented in Table 1.

Table 1

Identification, categorization and Classification of Risks in RMC Plants in India

No.	Category	Risks	Classification	
			Internal	External
1.	Political Risks	▪ Change in Govt. and Govt. policies		✓
		▪ War, Riots etc.		✓
		▪ Interference of local Politicos		✓

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Table 1 contd….

2.	Legal/Contractual Risks	▪ Contractual liability (breach, third party action)	✓	
		▪ Inappropriate dispute redressel mechanism	✓	
		▪ Conflict between various agencies	✓	
		▪ Errors in contract price calculation	✓	
		▪ Misinterpretation of contract terms	✓	
		▪ Litigation due to claim	✓	
		▪ Ambiguity in specification for delivery	✓	
3.	Environmental Risks	▪ Air Pollution	✓	
		▪ Water Pollution	✓	
		▪ Noise Pollution	✓	
		▪ Soil Pollution	✓	
		▪ Environmental Litigation		✓
		▪ Depletion of Natural resources	✓	
		▪ Extreme weather conditions (cold / hot)		✓
		▪ Damage to machineries due to flood		✓
		▪ Ineffective control over wastage	✓	
4.	Financial Risks	▪ Inflation		✓
		▪ Delay in Payment by client	✓	
		▪ Investment Risks	✓	
5.	Physical Risks	▪ Force Majeur(Acts of God)		✓
		▪ Disease / Epidemic		✓
		▪ Fire		✓
		▪ Terrorism		✓
		▪ Natural Disaster		✓
6.	Regulatory Risks	▪ Changes in local Tax rates		✓
		▪ Levy of additional taxes and duties on RMC (Entry Tax, Excise duty)		✓
		▪ Changes in current RMC regulations and ministry requirements		✓

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7.	**Operational Risks**	▪ Use of new technology	✓	
		▪ Lack of technical expertise / personnel	✓	
		▪ Internal technology system failure	✓	
		▪ Improper internal infrastructure	✓	
		▪ Improper site access	✓	
		▪ Confined spaces	✓	
		▪ regulatory and Govt. requirements for production		✓
		▪ Extended operational hours	✓	
		▪ Delay due to traffic during transportation		✓
		▪ Frequent breakdown of M/Cs, Plant etc.	✓	
		▪ Wrongly designed layout	✓	
		▪ Unskilled personnel to work on various operations	✓	
		▪ Idle machineries	✓	
		▪ Technical Risks – Policies and Procedure	✓	
		▪ Improper infrastructure, scaffolding and platform	✓	
		▪ Over utilization of plant capacity	✓	
		▪ Wrong working location	✓	
		▪ Improper erection and commissioning of Plant	✓	
		▪ High transportation cost	✓	
		▪ Lack of infrastructural facilities (water, roads, electricity, communication systems)	✓	
		▪ Use of ungraded machineries in manufacturing process	✓	
		▪ Damage to roads due to transporting through heavy vehicles	✓	
		▪ No flow through pipes during discharge of concrete at site.	✓	
8.	**Quality Risks**	▪ Varying degree of moisture in sand	✓	
		▪ Improper or no calibration of water meter, weigh balance, machines and equipments	✓	
		▪ Errors in testing and inspection of materials.	✓	
		▪ Non availability of advanced testing facilities.	✓	
		▪ Poor quality of repairs and maintenance	✓	

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Table 1 contd……

		▪ Inaccuracy in statistical adjustments	✓	
		▪ Risks of drying and loss of workability of concrete	✓	
		▪ Slump and sand content is not properly governed	✓	
		▪ Mixer not maintained in an efficient and clean condition	✓	
		▪ Improper moisture compensation	✓	
		▪ Incorrect Mix design	✓	
		▪ Improper specification for RMC		✓
		▪ Incorrect use of admixtures	✓	
		▪ Irregular quality monitoring	✓	
		▪ Inappropriate quality standards	✓	
		▪ Non conformance with basic properties of ready mix concrete like workability, strength, durability, setting time of concrete,loading wrong material, segregation and homogeneity during transport	✓	
		▪ Not using proper checklist for quality control	✓	
9.	**Procure ment and storage Risk**	▪ Non availability / shortage of cement and other materials	✓	
		▪ Transport strike		✓
		▪ Vender problems (delays)		✓
		▪ Accepting raw material at site without required specifications	✓	
		▪ Non availability of spare parts		✓
		▪ Difficulties in importing equipments		✓
		▪ Improper storage system (Dampness, no ventilation)	✓	
		▪ Theft at site	✓	
		▪ Risks associated with wrong decisions related to buying and /or hiring	✓	

Table 1 Contd………

9.	**Procurement and storage Risk**	▪ Non availability / shortage of cement and other materials	✓	
		▪ Transport strike		✓
		▪ Vender problems (delays)		✓
		▪ Accepting raw material at site without required specifications	✓	
		▪ Non availability of spare parts		✓
		▪ Difficulties in importing equipments		✓
		▪ Improper storage system (Dampness, no ventilation)	✓	
		▪ Theft at site	✓	
		▪ Risks associated with wrong decisions related to buying and /or hiring	✓	
10.	**Occupational and health Risks**	▪ Eye, skin and respiratory tract irritation	✓	
		▪ Chemical burns	✓	
		▪ Over exertion	✓	
		▪ Ergonomics	✓	
		▪ Occupational hazards faced by truck drivers	✓	
11.	**Safety Risks**	▪ Injuries at site	✓	
		▪ Slips, trips and falls	✓	
		▪ Accidents at plant site	✓	
		▪ Non functioning of fire fighting system at plant site	✓	
		▪ Non availability /no use of safety equipments and tools at plant site	✓	
		▪ Non availability of proper medical facilities	✓	
		▪ Mishandling of material at plant site	✓	
		▪ Accidents during transport of concrete	✓	
		▪ Death/Injury to someone at site or in plant due to accident	✓	
		▪ Not following manufacturers recommended practice for cleaning and lubricating etc	✓	
		▪ Not maintaining maintenance check sheet and repair records	✓	
		▪ No set up for regular testing and inspection	✓	

Contd..

Table 1 Contd…….……

		▪ Not doing major overhauling using services and expertise of manufacturer's representative or specialist/ experts.	✓	
		▪ Not replacing worn parts on regular basis	✓	
		▪ Not keeping hydraulic equipment free from contamination.	✓	
12.	**Market Risks**	▪ Demand – Supply Gap	✓	
		▪ Competition in Market		✓
		▪ Wrong assessment of market potential and demand estimation.	✓	
13.	**Social Risks**	▪ Problems created by nearby residents		✓
		▪ Public outcry with regard to activities like quarrying near plant etc		✓
14.	**Labor Related Risks**	▪ Non productivity / performance of laborers	✓	
		▪ Non availability of local labour		✓
		▪ High Labor turnover	✓	
		▪ Problems by labour union		✓
15.	**Organizational Risks**	▪ Cultural differences		✓
		▪ Performance risks	✓	
		▪ Improper planning for various works	✓	
		▪ Less growth opportunities within organization	✓	
16.	**Wastage Risks**	▪ Discharge of concrete on ground (slurry is lost)	✓	
		▪ No policy for solid waste and runoff management	✓	
		▪ Inappropriate disposal of sludge	✓	
		▪ Conveyance of waste water is not regulated properly	✓	
		▪ Inappropriate sewage treatment and disposal	✓	

Contd..

Table 1 contd……

17.	**Risks related to repairs and maintenance of plant**	▪ Low maintenance at plant	✓	
		▪ No careful planning for repairs and maintenance	✓	
		▪ No periodical check up of plant and machineries	✓	

3.2 Risks prioritization

Risks prioritization is done in order to screen the risks so that risks having substantial influence on RMC business objectives can be selected for quantification. For this, probabilities and consequences are assigned to individual risks on subjective basis using following tools.

- QRA sheet (Qualitative Risk Analysis sheet)

- P-C Matrix (Probability – Consequences Matrix)

3.2.1 QRA sheet

QRA Sheet is designed, in particular, to assess individual risks subjectively. It has a list of identified and categorized risks on the left hand side column of the sheet. It shall ask for probability and consequence of each risk in a subjective way. For probability assignment, a probability scale shall be used. This scale shall be used for assigning the probability, ranging subjectively from rare, unlikely, possible and likely to almost certain. In the context of risk consequences, the same scale shall be used. This scale shall be used for assigning consequences subjectively from insignificant, minor, moderate and major to catastrophic consequences.
Project managers and key personnel at respective RMC plants shall discuss as a team to decide the level of probability and consequences of individual risks. A QRA sheet (www.cholarisk.com) shall be filled after reaching consensus, where only tick marks shall be put in appropriate boxes in QRA sheet, for assigning probabilities and consequences to the individual risks (Table 2).

Table 2: QRA (Qualitative Risk Analysis sheet)

Identified and classified risk	Probability					Consequences				
	Rare	Unlikely	Possible	Likely	Almost certain	Insignificant	Minor	Moderate	Major	Catastrophic
A). Political Risk										
R1										
R2										
R3										
B). Contractual Risk										
R1										
R2										
R3										
R4										

3.2.2 Probability - Consequence Matrix

Response in QRA sheet shall be used to study the exposure of risks, using P-C Matrix (Probability-Consequence Matrix). It shall consist of vertical column for probability and horizontal column for consequences using the scale, same as that is used in QRA sheet. This matrix shall be used to express combined effect of probability and consequences associated with each risk. This combined effect shall be expressed as very low, low, significant and high, dividing P-C Matrix into four Zones as shown in table 3 (Hillson(b) 2002) .

Table 3: P-C Matrix

P \ C	In - signifi cant	Minor	Moderate	Major	Cates-tropic
Rare	Very Low	Very Low	Low	Low	Significant
Unlikely	Very Low	Low	Low	Signifi-cant	Significant
Possible	Low	Low	Signifi-cant	Signifi-cant	High
Likely	Low	Signifi-cant	Signifi-cant	High	High
Almost Certain	Signifi-cant	Signifi-cant	High	High	High

Risks falling in very low and low zones of P-C matrix shall be eliminated from quantification, as these risks shall have negligible effect on objectives of RMC business in terms of cost. Risks falling in "Significant" and "high zones" of P-C Matrix shall have potential Consequences on RMC business objectives in terms of cost and thus shall be considered for quantification. These risks shall actually have substantial influence on objective of a company running RMC plant and are to be taken into account for risk quantification.

4. Risk Quantification using EMV analysis

In this step of proposed approach, risks which actually may cause substantial cost increase shall be quantified to get an idea about total project risks in term of production and supply cost. A quantification format is proposed for this purpose, which shall be used to gather the data related to probability and consequences of the "significant" and high" exposure risks in term of cost. The effect of time factor i.e. cost related to delay shall also to be included in each risk. Team of project manager with key personnel at respective plants shall discuss together and after reaching consensus, shall fill required details about individual risks as well as about their interdependency, if exists. This approach is explained stepwise in the following paragraphs.

4.1 Assigning basic occurrence probability to selected risks

Team members shall decide about the probability of occurrence of risks i.e. chance of risks actually occurring, after discussing, brainstorming and reaching consensus. For example, the basic occurrence probability of a particular risk can be decided as 70% by the team members after reaching consensus. This means that there are 70% chances of occurrence of that particular risk and there shall be 30% chance of non occurrence of that particular risk.

4.2 Selecting scale for probabilities for different cost consequences

In the proposed system, scale for cost consequences shall be used where a range of cost consequences in terms percentage of the average monthly production and supply cost of RMC shall be given and associated probabilities shall be filled by team members after reaching consensus. This scale is shown below in Table 4.

Table 4: Scale with a Range of cost consequences and associated probabilities

Cost Consequences(In terms of Average Monthly Production and supply cost of RMC)	0-1% (In terms of average monthly production and supply cost of RMC – specify)	1%-2% (In terms of monthly production and supply cost of RMC - specify)	3% -5 % (In terms of the monthly producti-on and supply cost of RMC - specify)	5%-10 % (In terms of the monthly producti-on and supply cost of RMC (specify)	10 % and above (In terms of average monthly producti -on and supply cost of RMC - specify)
Probability					

(Here it means: What is the probability that consequences due to a particular risk will lead to 0-1% cost consequences (loss) with respect to the average monthly production and supply cost of RMC from the respective plant, 1 to 2% cost consequences (loss) with respect to the average monthly production and supply cost of RMC from the respective plant and so on).

Note: Above classes being mutually exclusive, sum of the probabilities for all the ranges of consequences should be 100%.

The scale for cost- consequences and associated probabilities is subjected to modification, considering various factors like age of the plant, technology adopted, seasonal variations in demand of RMC, monthly yearly turnover etc. Experience shall influence the responses while filling the above table.

4.3 Interdependence and cost consequences

It is not that all risks are independent. Many risks have interdependency relations with other risks, i.e. occurrence of one risk can lead to some effect on the cost consequences due to other risk. A quantification format is suggested for this purpose that shall be is used to get these details. There may be an increase or decrease in the cost consequences but these values are needed for the calculations proposed in this approach for risk quantification. The format for obtaining cost consequences due to independencies is presented below in Table 5.

Table 5: Interdependency Format

Effect on(say) Risk R1	% Increase in cost consequence	% Decrease in cost consequence
Due to occurrence of (say)Risk R2		
Due to occurrence of (say)Risk R3		
Due to occurrence of (say)Risk R4		

Respective team of project managers and key personnel, after reaching consensus, shall write the percentage increase or decrease in cost consequence of risks (loss) in term of average monthly production and supply cost. For example, as shown in Table 5, influence of say risks R2, R3 and R4 on say risk R1 can be filled by team members. This Format shall be used for interdependent risks to find changes in cost consequences

4.4 Calculations for risk quantification

In the proposed approach, Expected Monetary Value (EMV) analysis shall be used as a tool to carry out risk quantification. EMV is a product of risk event probability and risk event consequences. Risk event probability is an estimate of probability that a given risk will occur (Basic Occurrence probability).

The calculations using EMV analysis in the proposed risk quantification approach shall be as below -

1. The lowest and highest cost consequences related to each risk are considered as “Low1” and “High 1” values. As the consequences are described in scales, the mid-point of each class is taken as cost consequences for calculation.

Example – For class 1-2% - 1.5% taken for calculations
Similarly, For class 3-5% - 4% is taken for calculations

Expected Monetary Value 1 is calculated for every risk using following formula -

<u>Expected Monetary Value 1</u> = Cost consequence of an individual risk x *Probability of this cost consequence* *(Eqn-1)*

2. Next step is to consider basic occurrence probability of each risk and multiply it with its Expected Monetary Value1.This shall give Expected Monetary Value 2 for a particular risk. Thus,

<u>Expected Monetary Value 2</u> = Basic occurrence Probability of an individual risk x *Expected Monetary Value 1* *(Eqn-2)*

Modification is also applied to Expected Monetary Value 2 for interdependencies, in order to get Final Expected Monetary Value. Low 2, High 2 and Final Expected Monetary Value is determined using following formula. (Refer Table 4 for clarity of this formula)

<u>Low 2</u> = Low 1+ [(Low 1 x *%change in a particular risk say R1 due to occurrence of another risk say R2)* x *Basic occurrence probability of risk R2] + [(Low 1* x *%change in a particular risk say R1 due to occurrence of another risk say R3)* x *Basic Occurrence Probability of Risk R3] + [(Low 1* x *%change in a particular risk say R1, due to occurrence of another risk say R4)* x *Basic occurrence probability of risk R4]* *(Eqn-3)*

<u>High 2</u> = High 1+ [(High 1 x *%change in a particular risk say R1 due to occurrence of another risk say R2)* x *Basic occurrence probability of another risk R2] + [(High 1* x *%change in a particular risk say R1 due to occurrence of another risk say R3)* x *Basic Occurrence Probability of Risk R3] + [(High 1* x *%change in a particular risk say R1 due to occurrence of another risk say R4)* x *Basic occurrence probability of another risk R4]* *(Eqn-4)*

<u>Final Expected Monetary Value</u> = Expected Monetary Value 2 + [(Expected Monetary Value 2 x *%change in a particular risk say R1 due to occurrence of another risk say R2)* x *Basic Occurrence Probability of R2] + [(Expected Monetary Value 2* x *%change in a particular risk say R1 due to occurrence of another risk say R3)* x *Basic Occurrence Probability of R3] + [(Expected Monetary Value 2* x *%change in a particular risk say R1 due to occurrence of another risk say R4)* x *Basic Occurrence Probability of R4]* *(Eqn-5)*

The total risk, in terms of cost, varies between the sum of Low 2 values and sum of High 2 values, for all the risks considered for quantification. Proposed approach also gives the sum of Expected Monetary Value of all the risks, which is calculated in a proposed approach as ‘Final Expected Monetary Value’.

5. Conclusion

The proposed paper presents the risk quantification approach for internal as well as external risks in RMC plants. The information is gathered through the interviews and discussion with the team of key personnel working in RMC plants at Mumbai, Navi Mumbai, Noida, Bangalore, and Pune in India. A checklist of risk is generated as an outcome of this study. Subjective Ratings for both, probability of occurrence and consequences were also gathered from the same teams for screening the risks having substantial influence on objective of a company running RMC plants.

Risk quantification approach proposed in this paper, using EMV is a simple and effective tool to quantify risks in terms of cost. The system can be used to find -

- Range within which the individual risk (in terms of cost) may vary

- Range within which the total risks in RMC plant (in terms of cost) may vary

- Expected monetary value of the risks in RMC plant

The approach can be used by the RMC plant owners for deciding upon risk response strategies. It can be used fairly for decision making at the starting point of every RMC manufacturing and supply contract. It helps in identifying the high risk areas which need to be controlled and monitored for the achievement of objectives RMC business in terms of cost. This approach can be made suitable for incorporating and implementing with a computer aided decision support system, provided precise data is made available.

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